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From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

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Box PCT
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in its capacity as elected Office

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International filing date (day/month/year) 25 October 1999 (25.10.99)	**Priority date** (day/month/year) 26 October 1998 (26.10.98)
Applicant ECCLES, Christopher, Robert	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

25 May 2000 (25.05.00)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was
[ ] was not

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(71) Applicant *(for all designated States except US)*: AB TEKNISK UTVECKLING EHR [SE/SE]; Sköttorpsv. 1, S-772 00 Gränsgesberg (SE).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)* : HAEFFNER, Erik [SE/SE]; Eskadervägen 8, S-183 54 Täby (SE).

(74) Agents: ROSENQUIST, P., O. et al.; P O Rosenquist Patentbyrå AB, P O Box 260, S-151 23 Södertälje (SE).

(81) Designated States: AT (European patent), BE (European patent), CH (European patent), DE (European patent)*, DK (European patent), ES (European patent), FR (European patent), GB (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent), US.

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With international search report.
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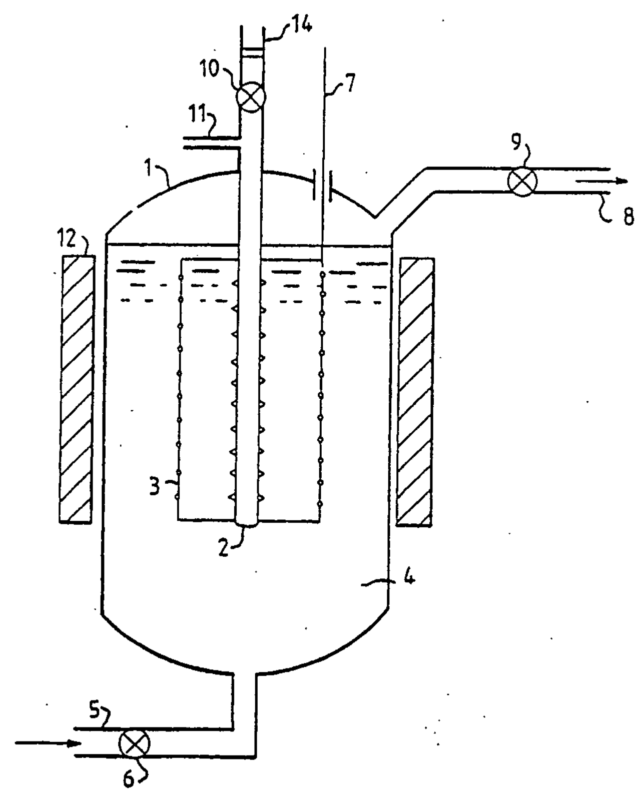
(54) Title: PRODUCTION OF FUSION ENERGY

(57) Abstract

By a high voltage electrical discharge, as an arc or sparks, between metal electrodes (2, 3) immersed in heavy water, D_2O, free deuterons, heavy hydrogen nuclei, with high kinetic energy, are generated and accelerated against the negative electrode. The deuterons are discharged on the electrode by capturing electrons and forming atoms D and molecules D_2, which are absorbed on the metal surface constituting a target for incident deuterons, whereby nuclear reactions, fusion of hydrogen nuclei, will occur. In an application of the invention the high voltage electrode (3) is inserted between the cathode (2) and the anode (13), constituting a cell for the electrolysis of heavy water. The cathode (2) and especially the surface layer will be saturated with D_2 and thereby the probability for fusion reactions with deuterons generated by intermittent discharges between the cathode (2) and the high voltage electrode (3) and hitting the cathode, will be considerably increased. The released fusion energy together with the supplied electrical energy can be recovered as high pressure steam.



ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.PCT/SE 90/00320

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the Swedish Patent Office EDP file on 90-06-27
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 4759894	88-07-26	CA-A- 1213083	86-10-21
		EP-A- 0114356	84-08-01
		JP-A- 59138983	84-08-09
US-A- 3437862	69-04-08	NONE	
US-A- 2728877	55-12-27	NONE	
US-A- 4836972	89-06-06	AU-B- 515071	81-03-12
		AU-D- 3211177	79-07-05
		CA-A- 1115862	82-01-05
		DE-A-C- 2758866	78-07-06
		FR-A-B- 2376497	78-07-28
		GB-A- 1555840	79-11-14
		JP-C- 1248123	85-01-16
		JP-A- 53102500	78-09-06
		JP-B- 59025194	84-06-15
		US-A- 4363775	82-12-14
US-A- 4793961	88-12-27	NONE	
US-A- 4853173	89-08-01	AU-D- 6724287	87-07-01
		EP-A- 0280684	88-09-07
		SE-B-C- 450060	87-06-01
		WO-A- 87/03416	87-06-04

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
X	US, A, 4793961 (EHLERS ET AL) 27 December 1988, see claims 1,9-11 --	1
X	US, A, 4853173 (STENBACKA) 1 August 1989, see abstract; claims 1,9-10 --	1
Y	Research News, Vol., April 1989 Robert Pool: "Fusion Followup: Confusion Abounds ", see page 27, column 1, line 35 - line 52 --	6,8
Y	L Recherche, Vol. 20, June 1989 Christian Amatore: "La fusion froide aura-t-elle lieu? ", ; figure 1 --	6,8

The process will be described in detail below with reference to the accompanying drawings, in which:

Figure 1 shows an apparatus according to the invention, and

Figure 2 shows an alternatively designed apparatus according to the invention.

In a tank (1) is provided an electrode system comprising a central electrode 2 in the shape of a rod or a pipe closed at its lower end and made of Pd, Ti or a metal alloy with great capacity of adsorbing hydrogen gas, and an outer electrode 3 in the shape of a tubular net or a perforated plate of platinum. The tank is filled with an electrolyte 4, such as heavy water, D_2O, pure or mixed with H_2O, which is supplied by the conduit 5 with the valve 6.

The outer electrode 3 is connected to the positive pole of a high voltage source by an electrical cable 5 and the central electrode 2 is connected to the negative pole by a cable 14. The high voltage source, e.g. a condenser is discharged by an electric arc between the electrodes 2 and 3. The time of duration, energy delivery and frequency of the spark should be variable within wide limits. Depending of the geometry of the electrolytic cell an optimum adjustment of these variables is done at the same time as the neutron density in the environment of the tank is an indicator that fusion reactions occur.

The water will be heated and vaporized by the supplied energy and the fusion energy. At a suitable steam pressure the steam is led out through a conduit 8 with a valve 9 and led to the heat exchanger and condenser. Thereafter the water is returned to the tank through the conduit 5 with the valve 6.

The central electrode, the tubular cathode 2, is preferably provided with short projections or flanges so that the increased field strength there will promote the formation of discharge sites. The pipe 2 may first be evacuated and then closed by a

valve 10. By coupling a branch pipe 11 to a vacuumeter penetrated deuterium is measured.

In an application of the invention the electrolyte consists of a 2 - 10 % by weight suspension in heavy water of magnetic particles e.g. magnetite, Fe_3O_4, of about 10 nm size. When a current flows through the plasma created by a spark or an electric arc in a high voltage discharge a magnetic field is formed which will considerably increase the apparent density around the plasma track. Thus the current itself will create a magnetic enclosure of the generated deuterons and other charged particles. This effect may be strengthened by surrounding the tank with a magnetic field, whereby the internal fluid pressure in the whole suspension D_2O - Fe_3O_4 can be substantially increased. Of course this effect cannot resist the pressure from the generated steam, which rapidly escapes, but after that the deuteron generating reactions in the spark has occured.

In a preferred embodiment of the invention the tank 1 is provided with a further electrode 13, functioning as the anode in an electrolytic cell wherein 2 is the cathode for the electrolytic decomposition of D_2O. The electrolyte 4 consists of D_2O and an added acid e.g. D_2SO_4, or an alkalideuteroxide, e.g. LiOD or KOD. The anode material can be Pt, Ni, or any other material generally used in electrolytic cells for water electrolysis.

The cell voltage can be between 2 and 12 V and the concentration of dissolved substances in the heavy water is about 0,1 M , but both higher and lower concentrations may work. The apparent density can also in this case be increased by the addition of suspended magnetic particles of a chemical composition which does not react with the electrolyte.

By the continuous electrolysis the cathode 2 is always saturated with D_2 thereby increasing the probability of fusion reactions by incoming high energy deuterons generated by the high voltage discharge between the electrodes 2 and 3. In this embodiment of the electrode system a diaphragm 15 is inserted to collect and

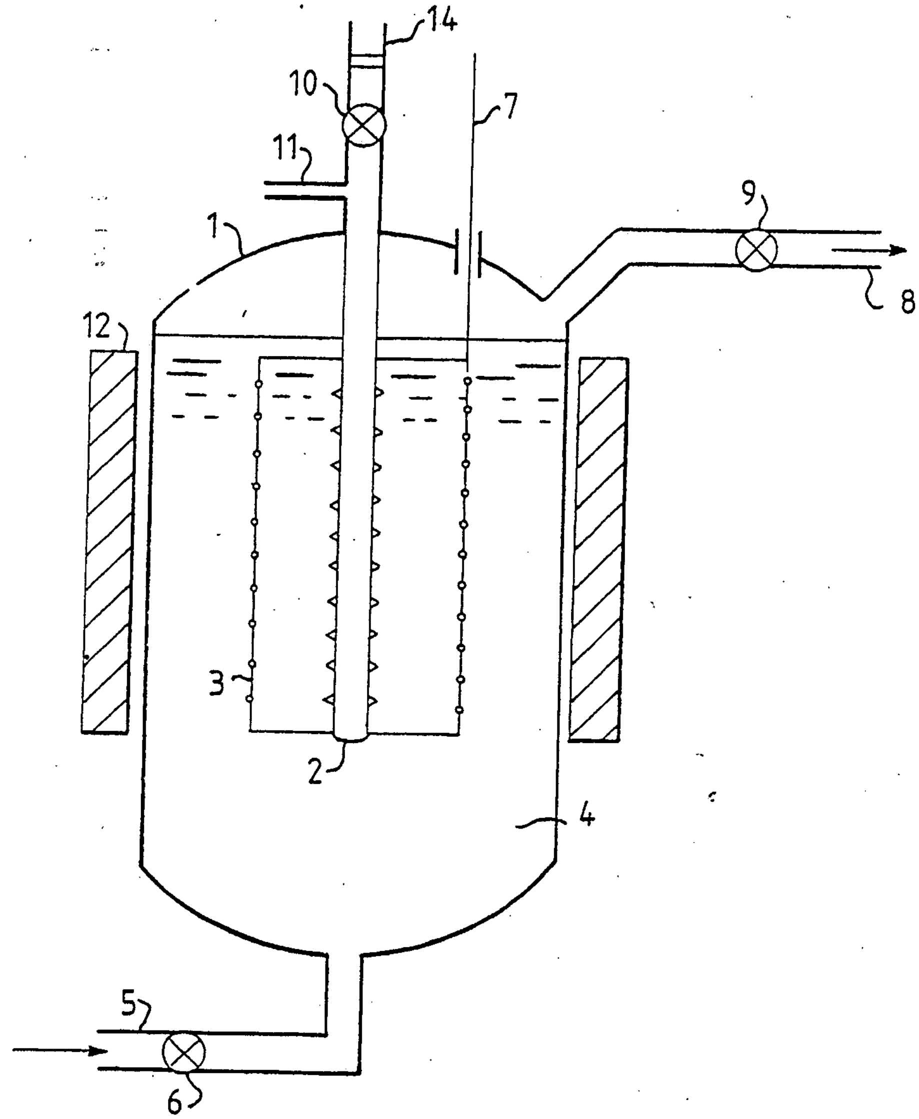

FIG. 1

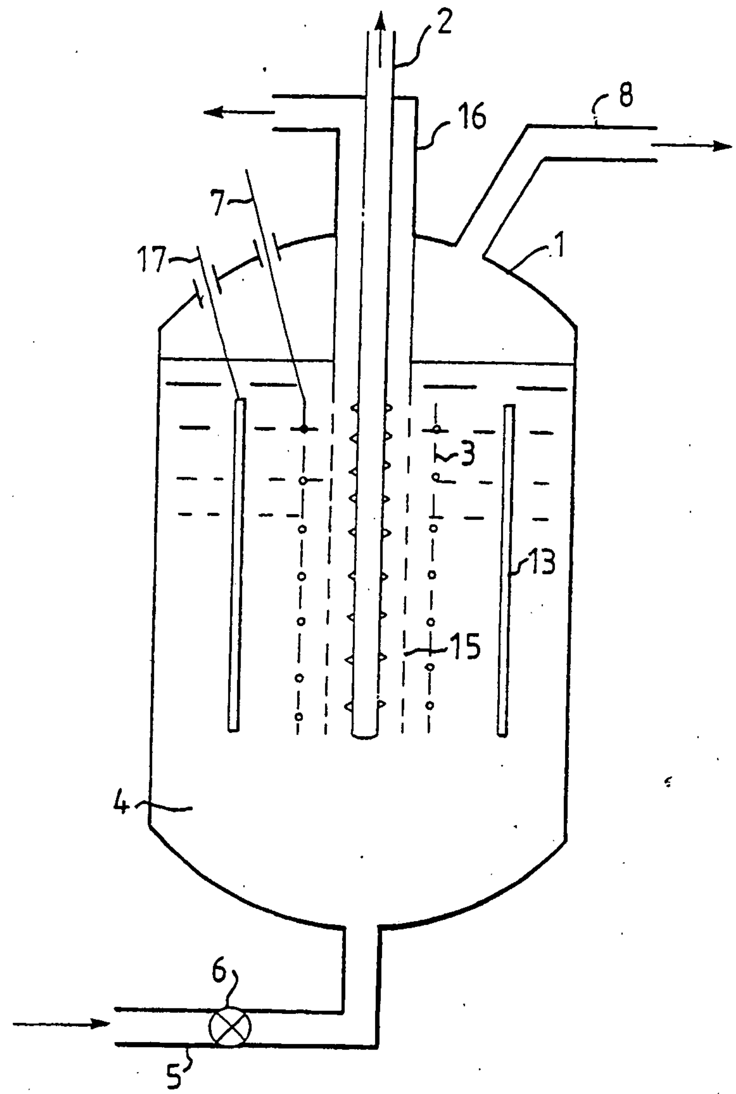

FIG. 2

SUBSTITUTE SHEET

INTERNATIONAL SEARCH REPORT

International Application No PCT/SE 90/00320

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC5: G 21 B 1/00

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
IPC5	G 21 B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched[8]

SE,DK,FI,NO classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category *	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
X	US, A, 4759894 (MCCORKLE) 26 July 1988, see column 10, line 49 - column 11, line 48; figure 3; claims 1-3,5	1-4,7
Y	--	6,8
X	US, A, 3437862 (W.W. SALISBURY) 8 April 1969, see claims 1,6,26 --	1
X	US, A, 2728877 (H.F. FISCHER) 27 December 1955, see column 4, line 32 - line 36; claim 1 --	1
X	US, A, 4836972 (BUSSARD ET AL) 6 June 1989, see claims 1,10 --	1

* Special categories of cited documents: [10]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
13th August 1990	1990 -08- 1 6
International Searching Authority	**Signature of Authorized Officer**
SWEDISH PATENT OFFICE	RUNE BENGTSSON Rune Bengtsson

Form PCT/ISA/210 (second sheet) (January 1985)

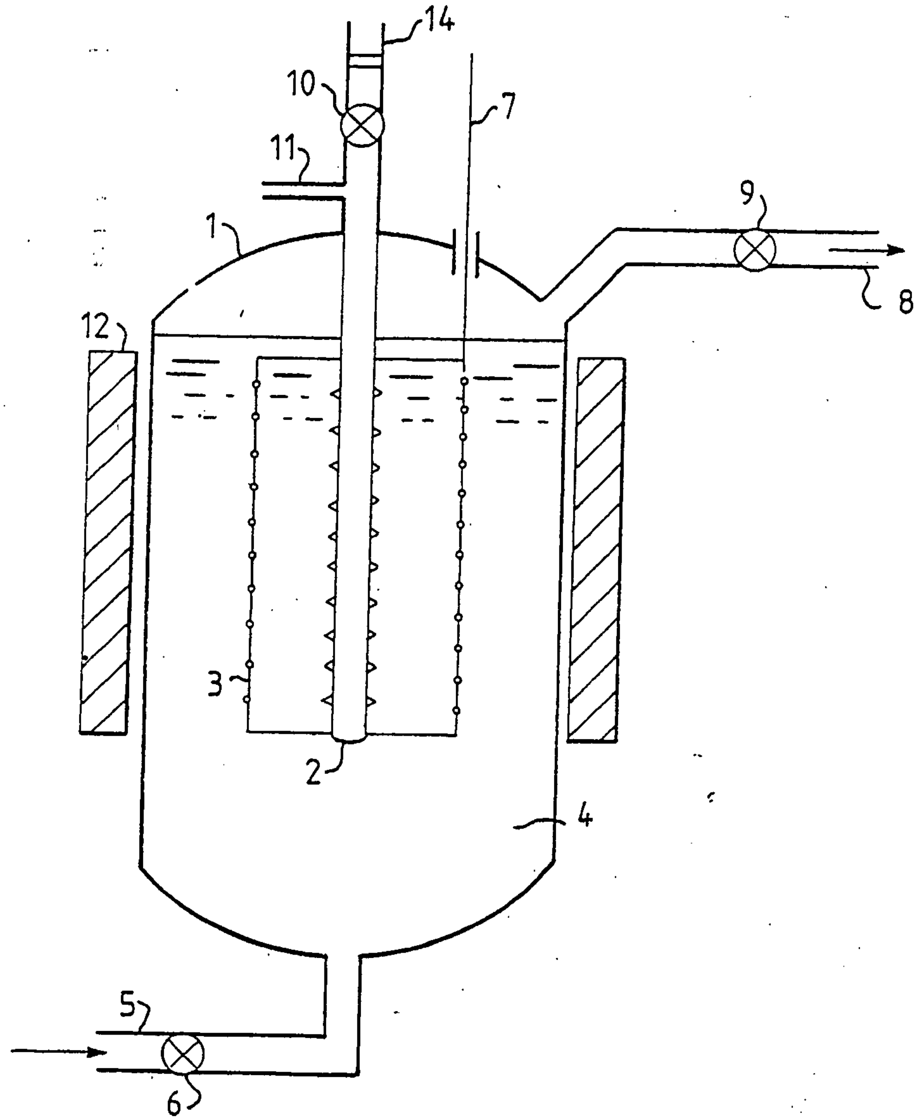

FIG. 1

also is cathode for the discharge.

7. Apparatus for use of the method according to the preceeding claims, **characterized in** that it comprises a tank (1) for electrolyte (4) with inlet (5) for electrolyte, outlet (8) for steam and valves (6,9), a central electrode (2) shaped as a rod or a tube functioning as cathode for the electrical discharge and provided with flanges or short projections, and a surrounding outer electrode, anode, (3) in the shape of a net or a perforated plate, and connections (7,14) to a high voltage source.

8. Apparatus according to claim 7, **characterized in** that the central electrode (2) consists of palladium or titan, the outer electrode (3) of platinum and the electrolyte (4) of heavy water, D_2O, or an alkali metal deuteroxide or D_2SO_4 dissolved in heavy water.

9. Apparatus according to claim 7 or 8, **characterized in** that a further tubular electrode (13) is arranged as anode for the decomposition electrolysis having connections (17,18) between the respective electrodes (13,2) and a low voltage source, and that a diaphragm (15) with an outlet pipe (16) for D_2 is surrounding the electrode (2).

10. Apparatus according to any of the claims 7 - 9, **characterized in** that particles of a ferromagnetic material with a diameter of about 10 nm are suspended in the electrolyte (4), and that the tank (1) is surrounded by a magnetic field (12).

lead away the generated D_2 through the pipe 16.

High voltage for the electrical discharge in the fluid is applied through the conduit 7 and low voltage for the electrolysis is applied through the conduit 17 to the anode 13.

List of details:

1. Tank
2. Central electrode, cathode
3. Outer electrode for high voltage discharge
4. Electrolyte
5. Conduit
6. Valve
7. High voltage conduit
8. Steam conduit
9. Valve
10. Valve
11. Branch pipe
12. Magnetic field
13. Electrode
14. Low voltage conduit
15. Diaphragm.
16. Pipe for D_2
17. Low voltage conduit

Claims

1. Method of generating energy from fusion of light atomic nuclei, preferably hydrogen isotopes, **characterized in** that a process comprises several unit processes, each fullfilling at least one of the following functions:
- generating a plasma containing protons, deuterons or tritons,
- generating an electrical field to accelerate said ions onto a target containing or covered by a layer of atomic or chemically bound hydrogen isotopes
- continuously renewing the hydrogen layer on the radiation target, and
- transforming the heat generated by the nuclear fusion reactions to pressurized water for use in known heat power processes.

2. Method according to claim 1, **characterized in** that during the acceleration the plasma is encased in a magnetic fluid.

3. Method according to claim 1 or 2, **characterized in** that a high voltage of preferably more than 20 kV is discharged through an electrical arc or spark between two electrodes constituting a cathode and an anode immersed in heavy water, D_2O, and that the discharge is continuous or intermittent.

4. Method according to any of the claims 1 - 3, **characterized in** that the heavy water is pressurized, preferably to about 10 MPa.

5. Method according to any of the preceeding claims, **characterized in** that the heavy water contains a supension of solid particles of a ferromagnetic material with a diameter of about 10 nm.

6. Method according to any of the preceeding claims, **characterized in** that the discharge occurs in an electrolysis cell for decomposition of heavy water, and that the cathode thereby

sorption of the heavy hydrogen gas in the Pd-metal and formation of D_2-molecules, might occur through the intermediation of so-called quasi-particles (muons) with one negative electron charge but with bigger mass than the electron mass. A muon with larger mass than the electron mass m_e has the ability to bind deuterons d more close in the molecule D_2. It has been calculated that a muon with the mass 5 m_e would decrease the distance between the d nuclei to about 0.15 Å. In this distance the repellant Coulomb potential is about 95 eV and the probability for a penetration through the potential barrier because of quantum mechanical tunnel effects is still low. The probability of tunnel effects would however increase considerably if the deuterons could be given a higher kinetic energy.

The method according to the invention is characterized in that it comprises a number of unit processes each complying with at least one of the following functions:

- generating a plasma containing protons, deuterons, or tritons,
- generating an electrical field for acceleration of said ions towards a target containing or covered with a layer of free or chemically bound heavy hydrogen isotopes,
- continuously regenerating the hydrogen layer on the radiation target, and
- transferring the heat released by the nuclei fusion to pressurized water for use in known heat power processes.

The apparatus according to the invention comprises a tank with electrolyte inlet and damp outlet with valves, a central tube or rod electrode with flanges or short projections, a surrounding electrode in the shape of a net or a perforated plate, and cables to a high voltage source.

The principle of the method to obtain nuclear fusion according to the invention is to combine mentioned unit processes and there included physical effects to maximize the probability of reactions d + d or p + d to such an extent that industrial energy production is feasible.

PRODUCTION OF FUSION ENERGY

This invention relates to a method of generating energy from the fusion of light atomic nuclei, preferably isotopes of hydrogen, and an apparatus for performing the method.

Since many years considerable research has been pursued with the purpose of obtaining fusion of light nuclei, such as deuterons, d, protons, p, and tritons, t, to generate energy in a manageable form for industrial and other use.

This fusion research has primarily been concentrated on methods to obtain a magnetic containment of a plasma at a high enough temperature and with such a deuteron density, that a fusion reaction will occur according to the well-known reaction:

$$d + d = {}^{3}He\ (0,82\ MeV) + n\ (2,45\ MeV). \qquad I$$

In spite of very considerable efforts this line of research has not yet definitively proved that it may result in an industrial process of energy conversion, primarily due to the fact that the necessary temperature and density of the plasma cannot be maintained for a sufficiently long time.

The probability that a fusion will occur in a plasma usually is described as a quotient, $T \times n \times \tau$, of the prevailing temperature, $T^{o}K$, deuteron density, $n\ g/m^3$, and time τ in seconds. In a preferred apparatus according to the invention, the value of $T \times n \times \tau$ can be calculated to be high enough for fusion reactions to occur at a rate of interest for practical use.

Recently a possibility to obtain so-called "cold fusion", principally an electrolysis of heavy water with a palladium cathode and an anode of platinum or gold, has been proposed and tested - so far without conclusive results. Theoretically it was speculated that fusion reactions under such circumstances, after ab-

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9904909.0	3 March 1999 (03.03.99)	GB

(71) Applicants *(for all designated States except US)*: DAVIES, Christopher, John [GB/GB]; Westgate House, Dedham, Colchester, Essex CO7 6HJ (GB). DAVIES, Caroline, Jane [GB/GB]; Westgate House, Dedham, Colchester, Essex CO7 6HJ (GB). BEITH, Robert, Michael, Victor [GB/GB]; Wall View, Easton, Woodbridge, Suffolk IP13 0EF (GB).

(71)(72) Applicant and Inventor: ECCLES, Christopher, Robert [GB/GB]; Westgate House, Colchester, Essex CO7 6HJ (GB).

(74) Agent: HITCHCOCK, Esmond, Antony; Lloyd Wise, Tregear & Co., Commonwealth House, 1–19 New Oxford Street, London WC1A 1LW (GB).

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Published
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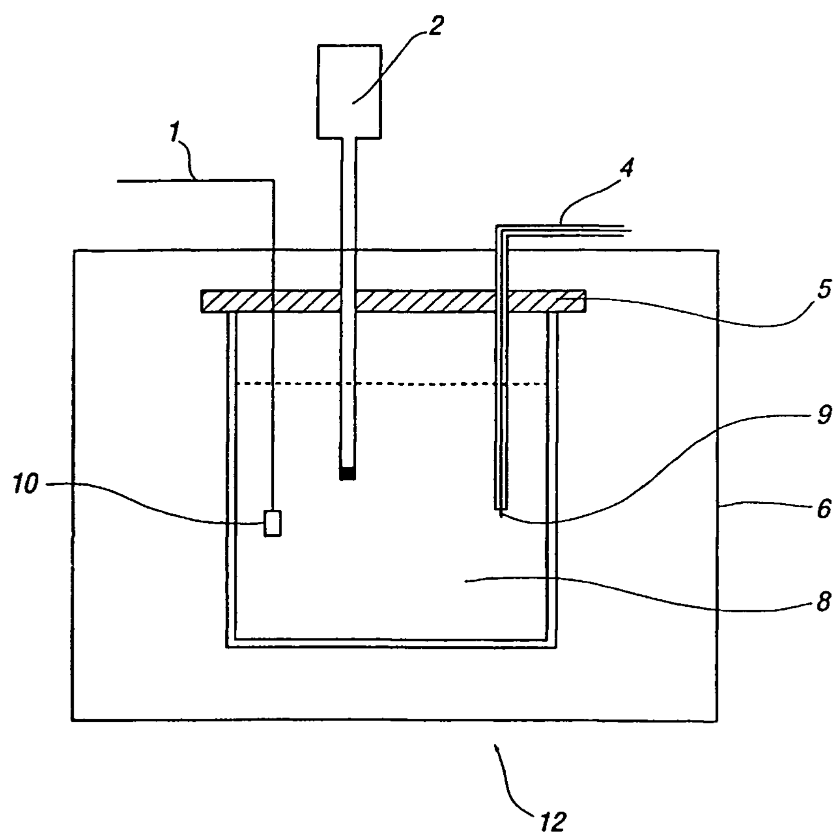
(54) Title: ENERGY GENERATION

(57) Abstract

Methods and apparatus are described for releasing energy from hydrogen and/or deuterium atoms. An electrolyte is provided which has a catalyst therein suitable for initiating transitions of hydrogen and/or deuterium atoms in the electrolyte to a subground energy state. A plasma discharge is generated in the electrolyte to release energy by fusing the atoms together.



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ENERGY GENERATION

The present invention relates to the generation of energy, and more particularly to the release of energy as a result of both a state-transition in hydrogen and fusion of light atomic nuclei.

Normally, fusion processes are able to be initiated only at extremely high temperatures, as found in the vicinity of a nuclear fusion (uranium or plutonium) detonation. This is the principle of most thermonuclear bombs. Such a release of energy is impractical as a means of providing the power to generate electricity and heat for distribution, as it occurs too rapidly with too high a magnitude for it to be manageable.

In recent years, many attempts have been made to initiate controlled fusion processes at high temperatures by the enclosure of a region of plasma-discharge within a confined space, such as a toroidal chamber, using electromagnetic restraint. Such attempts have met with little commercial success to date as systems which employ such a technique have so far consumed more energy than they have produced and are not continuous processes.

Another approach which has been attempted in order to achieve fusion of light nuclei has been the so-called "cold fusion" technique, in which deuterium atoms have been induced to tunnel into the crystal lattice of a metal such as palladium during electrolysis. It is claimed that the atoms are forced together in the lattice, overcoming the repulsive electrostatic force. However, no clear and unambiguous demonstration of successful cold fusion has yet been presented publicly.

The present invention provides a method of releasing energy comprising the steps of providing an electrolyte having a catalyst therein, the catalyst being suitable for initiating transitions of hydrogen and/or deuterium atoms in the electrolyte to a sub-ground energy state, and generating a plasma discharge

in the electrolyte. The applicants have determined that this method generates substantially more energy than the power input used to generate the plasma, whilst doing so in a controllable manner.

Preferably, the plasma discharge is generated by applying a voltage across electrodes in the electrolyte and an intermittent voltage has proved particularly beneficial in increasing the level of energy generation. It also provides a means of controlling the process to maintain a consistent level of energy production over a significant period of time.

The application of a voltage higher than that necessary to generate plasma is also beneficial to the process and will be typically in the range 50V to 20000V and preferably between 300 and 2000V, but may be higher than 20000V, whereas in conventional electrolysis techniques low voltages of about 3 volts are used and applied continuously across the electrodes.

The applied voltage may be DC or provided at a switching frequency of up to 100 kHz. The duty cycle of the applied voltage is preferably in the range 0.5 to 0.001, but may be even lower than 0.001. During the pulse period a monomolecular layer of metal hydride may be formed at the cathode-Helmholtz layer interface and subsequently decays to form gas in the nascent state comprising monatomic hydrogen and/or deuterium. The waveform of the applied voltage may be substantially square shaped. Whilst application of DC to the electrode does produce the metal hydride and monatomic hydrogen and/or deuterium, the use of a pulsed voltage has been found to be more efficient as most dissociation of the hydride then occurs between the pulses.

In applications where the electrolyte is flowed past the electrodes it may be preferable to use two separate cathodes, the first of which will be engineered to optimise production of hydrogen/deuterium atoms and the second of which will provide the plasma discharge. In this instance the direction of flow of the

electrolyte is from first to second cathode. The design of the apparatus seeks to direct the flow of electrolyte to maximise contact of monatomic hydrogen or deuterium atoms with the plasma. The characteristics and magnitudes of the voltages applied to each cathode are preferably similar, but may have different duty periods.

In a preferred embodiment, the cathode design and applied voltage are such as to provide a current density of 400,000 amps per square metre or even greater. More preferably, the current density at the cathode is 500,000 amps per square metre or above.

In carrying out a preferred method in accordance with the invention, it has been found that the process may be assisted by initial heating of the electrolyte, which may be water or a salt solution, prior to applying electrical input to the vessel. A temperature in the range 40 to 100°C, or more preferably 40 to 80°C, has been found to be particularly beneficial.

The ratio of water to deuterium oxide (D_20) in the electrolyte may be varied to control the energy generation. In some circumstances it may be preferable to use "light" water H_20 alone and in others to use D_20 alone. Additionally, the amount of catalyst added to the electrolyte may be varied as a controlling factor and preferably lies in the range 1 to 20 mMol.

In preferred embodiments, the method includes the step of generating a magnetic field in the region of the electrodes. The intensity and/or frequency of the current used to generate the field may be adjusted to move the plasma discharge away from the electrode from which it is struck in order to minimise erosion and extend the operating life of the system. Only slight separation may be required to achieve this effect.

In further preferred embodiments, the heat generated by the process may be removed and utilised by way of a number of known and proven technologies including the circulation of the

electrolyte through a heat exchanger, or using heat pipes to produce heating, or alternatively to produce electricity using a pressurised steam cycle or a low-boiling-point fluid turbine cycle, or by other means.

The present invention further provides apparatus for carrying out methods disclosed herein comprising an anode, first and second cathodes, a reaction vessel having an inlet and an outlet, means for feeding an electrolyte through the vessel from its inlet to its outlet, the electrolyte having a catalyst therein suitable for initiating transitions of hydrogen and/or deuterium atoms in the electrolyte to a sub-ground energy state, means for applying a voltage across the anode and the first cathode to form hydrogen and/or deuterium atoms, and means for applying a voltage across the anode and second cathode to generate a plasma discharge in the electrolyte, the second cathode being downstream from the first cathode.

During the methods described herein, atoms of hydrogen and/or deuterium are believed to undergo a fundamental change in their structure by exchange of photons with salts in solution. The applicants believe that this change, and the observed phenomena, can be explained as set out below.

It is well known that a system comprising a spherical shell of charge (the electron path) located around an atomic nucleus constitutes a resonant cavity. Resonant systems act as the repository of photon energy of discrete frequencies. The absorbtion of energy by a resonant system excites the system to a higher-energy state. For any spherical resonant cavity, the relationship between a permitted radius and the wavelength of the absorbed photon is:

$$2\pi r = n\lambda$$

where n is an integer
and λ is the wavelength

For non-radiating or stable states, the relationship between the electron wavelength and the allowed radii is:

$$2\pi[nr_1] = 2\pi r_{(n)} = n\lambda_{(1)} = \lambda_{(n)} \quad (2)$$

where $n = 1$
or $n = 2, 3, 4 \ldots\ldots\ldots$
or $n = 1/2, 1/3, 1/4 \ldots\ldots\ldots$

and $\lambda_{(1)}$ = the allowed wavelength for $n = 1$
$r_{(1)}$ = the allowed radius for $n = 1$

In a hydrogen atom (and the following applies equally to a deuterium atom), the ground state electron-path radius can be defined as $r_{(0)}$. This is sometimes referred to as the Bohr radius, a_0. There is normally no spontaneous photon emission from a ground state atom and thus there must be a balance between the centripetal and the electric forces present. Thus:

$$[m_{(e)}.v_1^2]/r_{(0)} = Ze^2/(4\pi.\epsilon_{(0)}.r_{(0)}^2) \quad (3)$$

where $m_{(e)}$ = electron rest mass
v_1 = ground state electron velocity
e = elementary charge
$\epsilon_{(0)}$ = electric constant (sometimes referred to as the permittivity of free space)
Z = atomic number (for hydrogen, 1)

Looking first at the excited (higher energy) states, where the hydrogen atom has absorbed photon(s) of discrete wavelength/frequency (and hence energy), the system is again stable and normally non-radiating, and to maintain force balance, the effective nuclear charge becomes $Z_{eff} = Z/n$, and the balance equation becomes:

$$[m_{(e)}.v_n^2]/nr_{(0)} = [e^2/n]/(4\pi.\epsilon_{(0)}.[nr_{(0)}]^2) \quad (4)$$

where n = integer value of excited state (1,2,3.....)
v_n = electron velocity in the nth excited state

The absorbtion of radiation by an atom thus results in an excited state which may decay to ground state, or to a lower excited state, spontaneously, or be triggered to do so, resulting in the re-release of a quantum of energy in the form of a photon. In any system consisting of a large number of atoms, transitions between states are occurring continuously and randomly and this activity gives rise to the observable spectra of emitted radiation from hydrogen.

Each value of n corresponds to a transition which is permitted to occur when a resonant photon is absorbed by the atom. Integer values of n represent the absorbtion of energy by the atom.

Fractional values for n are allowed by the relationship between the standing wavelength of the electron and the radius of the electron-path, given by (2), above. To maintain force balance, transitions involving fractional values for n must effectively increase the nuclear charge Z to a figure Z_{eff}, and reduce the radius of the electron-path accordingly. This is equivalent to the atom emitting a photon of energy while in the accepted ground state, effecting a transition to a sub-ground state. Because the accepted ground state is a very stable one, such transitions are rarely encountered but the applicants have discovered that they can be induced if the atom is in close proximity to another system which acts as a "receptor-site" for the exact energy quantum required to effect the transition.

The emission of energy by a hydrogen atom in this way is not limited to a single transition "down" from ground state, but can occur repetitively and, possibly, transitions to 1/3, 1/4, 1/5 etc states may occur as a single event if the energy balance of the atom and the catalytic system is favourable. Of course, the usual uncertainty principles forbid the determination of the behaviour of any individual atom, but statistical rules govern

the properties of any macroscopic ($>10^9$ quanta) system.

When a "ground-state" hydrogen atom emits a photon of around 27eV, the transition occurs to the $a_0/2$ state as demonstrated above and the effective nuclear charge increases to +2e. A new equilibrium for the force balance is now established. The electron path radius is reduced. The potential energy of the atom in its reduced radius-state is given by

$$V = -\{Z_{(eff)}e^2/[4\pi\epsilon_{(0)}(a_{(0)}/2)]\} = -\{4 \times 27.178\}$$

$$= -108.7 \text{ eV}$$

The kinetic energy, T, of the reduced electron path is given by

$$T = -[V/2] = 54.35 \text{ eV}$$

Similarly, it can be seen that the kinetic energy of the ground state electron path is about 13.6 eV. Thus there is a net change in energy of about 41 eV for the transition:

$$H\{Z_{(eff)}=1;\ r=a_{(0)}\} \quad \text{to} \quad H\{Z_{(eff)}=2;\ r=a_{(0)}/2\}$$

That is to say, of this 41 eV, about 27 eV is emitted as the catalytic transfer of energy occurs, and the remaining 14 eV is emitted on restablisation to the force balance.

The radial "ground-state" field can be considered as a superposition of Fourier components. If integral Fourier components of energy equal to m x 27.2 eV are removed, the positive electric field inside the electron path radius increases by

$$(m) \times 1.602 \times 10^{-19}\text{C}$$

The resultant electric field is a time-harmonic solution of the Laplace equations in spherical co-ordinates. In the case of the

reduced radius hydrogen atom, the radius at which force balance and the non-radiative condition are achieved is given by

$$r_{(m)} = a_{(o)}/[m+1]$$

where m is an integer.

From the energy change equations given above, it will be appreciated that, in decaying to this radius from the so-called "ground-state", the atom emits a total energy equal to

$$[(m+1)^2 - 1^2] \times 13.59 \text{ eV} \qquad (5)$$

The applicants have found that such energy emissions as take place according to (5), above, only appear to occur when the hydrogen or deuterium is found in the monatomic (or so-called "nascent") state. Molecular hydrogen might be made to behave similarly, but the transition is more difficult to achieve owing to the higher energies involved.

In order to achieve the transition in monatomic hydrogen (H) or deuterium (D), it is necessary to accumulate the molecular form in the gas phase on a substrate such as nickel or tungsten which favours the dissociation of the molecule. As well as being dissociated into the monatomic form, the hydrogen or deuterium should be bound to the catalytic system to initiate the reaction. The preferred method of achieving this is by electrolysis using cathode material which favours dissociation.

The applicants have discovered that the catalytic systems which encourage transitions to sub-ground-state energies are those which offer a near-perfect energy couple to the [m x 27.2] eV needed to "flip" the atom of H or D. It appears from experiment that the effective sink of energy provided by the catalyst need not be precisely equal to that emitted by the atom. Successful transitions have been achieved when there is an error of as much as ±2% between the energy emitted by the atom and that absorbed

by the catalytic system. One possible explanation for this is that, in a macroscopic sized system, although the transitions are initiated by a close match in energy level, such discrepancies as arise are manifested as an overall loss or gain in the kinetic energies of the recipient ionic systems. It is thought that spectroscopic analysis of active H or D catalytic systems may provide evidence of this.

One catalyst that has been found to initiate the transition to the a_0/n state is rubidium in the Rb+ ionic species. If a salt of rubidium, such as the carbonate Rb_2CO_3 is dissolved in either water or deuterium oxide (heavy water), a substantial dissociation into Rb^+ and $(CO_3)^{2-}$ ions takes place. If the Rb^+ ions are bound closely to monatomic H or D, the transition to the a_0/n state is encouraged by the removal of a further electron from the rubidium ion, by provision of its second ionisation energy of about 27.28 eV. Thus:

$$Rb^+ + H\{a_{(0)}/p\} + 27.28\ eV \rightarrow$$

$$Rb^{2+} + e^- + H\{a_{(0)}/[p+1]\} + \{[(p+1)^2 - p^2] \times 13.59\}\ eV$$

where p represents an integral number of such transitions for any given H and D atom and by spontaneous re-association:

$$Rb^{2+} + e^- = Rb^+ + 27.28\ eV$$

Thus, the rubidium catalyst remains unchanged in the reaction and there is a net yield of energy per transition.

Other catalytic systems can be used which have ionisation energies approximating to [m x 27.2]eV, such as titanium in the form of Ti^{2+} ions and potassium in the form of K^+ ions.

The applicants believe that the above explanation is consistent with currently accepted quantum theory as discussed below.

Commencing with the equations of Rydberg and Schrödinger it can be shown that fractional numbers for the quantum energy states in hydrogen yield possible transitions which result in emissions at frequencies which are in accord with observed UV and X-ray spectra. It is therefore possible that the conditions conducive to initiating such transitions may be artificially reproduced in the laboratory under certain circumstances.

The Rydberg formula for the frequency of emitted radiation from a transition in monatomic hydrogen is:

$$v = R_{(h)}c(1/n_{(2)}^2-1/n_{(1)}^2)$$

where:

v is the frequency of the emitted photon

$R_{(h)}$ is Rydberg constant, 1.097373 c 10^7 m^{-1}

c is the speed of light in vacuo, 2.997 x 10^3 ms^{-1}

and

$n_{(1)}$, $n_{(2)}$ are the transition states

It can be seen from the above that, if the resultant energy state of the hydrogen atom is that which requires $n_{(2)}$ to be equal to 1/2, emissions will occur which are of higher frequency than the observed Lyman 2-1 transition in the ultra-violet at 2.467 x 1^{o15}Hz (about 121 nm). There is, indeed, an observed emission at a wavelength of about 30.8 nm, which appears to be confirmed by recent studies of galactic cluster emissions by Böhringer et al (Scientific American, January 1999) and it is difficult for the inventor to conceive of any other quantum-mechanical event which would give rise to such an emission, other than a transition, in accord with the above theory, from 1 to 1/2 in nascent hydrogen.

As can be seen from the above use of the standard Rydberg equation, such behaviour of hydrogen in the monatomic state views the conventional hydrogen "ground-state" as one of many stable electronically-preferred states for single H atoms.

To summarise, a proliferation of H or D atoms is produced which may have had significantly diminished electron-path-radii by virtue of exchange of photons with their environment. These atoms appear to be relatively unreactive chemically and appear not to readily take the molecular form H-H or D-D. This is a fortunate property which has significance and enables fusion pathways, as described below.

The fusion of light nuclei, hydrogen and deuterium, to form heavier elements such as helium is one which has traditionally been encouraged by subjecting the reactants to extremes of temperature and pressure. This has been necessary because there is a large electric charge barrier to overcome in order to bring nuclei close enough for fusion to occur.

Using atoms with diminished electron path radius, adjacent nuclei may experience a corresponding reduction in electric barrier and internuclear separations may become smaller. With reductions in internuclear separation, fusion processes become more probable, and more easily occasioned.

There are two principle fusion pathways for deuterium atoms. The first is:

$${}^{2}_{1}D + {}^{2}_{1}D = {}^{3}_{2}He + {}^{1}_{0}n$$

where two deuterium nuclei fuse to produce an isotope of helium and a free neutron, which subsequently decays (half-life 6.48 x 10^{2}S), with emission of a $ß^{-}$ particle of medium energy (about 0.8Mev), and a type of neutrino, to become a stable proton.

The second is:

$${}^{2}_{1}D + {}^{2}_{1}D = {}^{3}_{1}T + {}^{1}_{1}H$$

where the two deuterium nuclei fuse to produce the isotope of hydrogen known as tritium (T) and a free stable proton. The tritium eventually decays (half-life 12.3 years), with emission of a β^- particle of very low energy (about 0.018 MeV), to become ${}^{3}_{2}He$

Of the two, the second fusion path is preferred for the peaceful exploitation of its energy yield, because the fusion products are (relatively) harmless on production, and decay to completely innocuous species within a short time, emitting radiation which can be effectively shielded by a thin sheet of kitchen foil or by 10 mm of acrylic plastic, for example.

When deuterium nuclei are forced together under high temperature and pressure conditions (as in a thermonuclear bomb), there is a greater than 50% probability for the first pathway to be the dominant one. This is because the high temperature process takes no account of nuclear alignment at the point of fusion. It is actually a matter of forcing nucleic together indiscriminately and hoping that enough fuse to produce an explosion. However, the applicants believe, in accord with established theory, that it is the alignment of the nuclei with respect to the charges in each nucleus which ultimately determines the favourable fusion path.

In order to achieve a higher probability for the second, less hazardous, pathway, the approaching nuclei need to have time to align electrostatically such that the proton-proton separation is at a maximum. This can only be achieved at far lower energies than those found in a thermonuclear bomb. By the use of entities with diminished electron-path-radii, and correspondingly potentially smaller internuclear distances, fusion can be initiated at lower temperatures (and consequently lower

energies), allowing for the charge-related alignment necessary to achieve a high probability for the second, tritium-forming, pathway. By introducing deuterium of diminished electron-path-radius into a plasma discharge which is confined within the water in the vessel itself, fusion is may be initiated. Temperatures of the order of 6000 K are obtained within certain plasma discharges and this, coupled with multiple quantum transitions to produce deuterium of diminished electron-path-radius, produces a substantial yield of energy from the two-stage process.

Another possible but less likely fusion pathway for hydrogen atoms is:

$$ {}^{1}_{1}H + {}^{1}_{1}H = {}^{2}_{1}D + ß^{+} + \tau $$

whereby $ß^{+}$ is produced as one of the products.

Embodiments of the invention will now be described by way of example and with reference to the accompanying schematic drawings, wherein:

Figure 1 shows an apparatus for carrying out a method in accordance with the invention on a relatively small scale;

Figure 2 shows a system for operating and measuring the performance of the apparatus of Figure 1;

Figure 3 shows a circuit diagram high voltage, high frequency switching circuit for the system of Figure 2;

Figure 4 shows an apparatus for carrying out a method in accordance with the invention on a larger scale than that of the Figure 1 apparatus; and

Figure 5 shows a further apparatus for carrying out a method of the invention which includes two cathodes.

The apparatus of Figure 1 enables the generation of energy according to the principles of the invention in the laboratory. Any risk of thermal runaway is minimised, whilst demonstrating that the level of energy release from the two stages is far in

excess of that which would result from any purely chemical or electrochemical activity. It also enables easy calorimetry, safe ducting away of off-gases, and of subsequent extraction of liquid for titration (to demonstrate that no chemical action takes place during the operation of the apparatus).

A 250ml beaker is provided with a glass quilt or expanded polystyrene surround 6 to act as insulation. This can include an inspection cut-out so that the area around the cathode 9 can be observed from outside. The beaker contains 200 ml of water, into which is dissolved a small quantity of potassium carbonate so as to give a solution of approximately 2 mMol strength. A platinum lead wire 1 is earthed to the laboratory reference ground plane. The anode 10, a sheet of platinum foil of approximately 10mm^2 in area, is attached to this lead wire by mechanical crimping. A digital thermometer 2 is inserted into the liquid in the vessel. A 0.25mm diameter tungsten wire cathode 9 is sheathed in borosilicate glass or ceramic tube 4 and sealed at the end immersed in the electrolyte so as to expose 10mm to 20mm of wire in contact with the liquid. The entire assembly of lead wires and the thermometer is carried by an acrylic plate 5 which enables of easy dismantling and inspection of the apparatus.

A supply of up to 360 volts DC, capable of supplying up to 2 amperes, is arranged external to the described apparatus. The positive terminal of this supply is connected to the laboratory reference ground plane and the negative terminal is connected to one pole of an isolated high-voltage switching unit. The other pole of the switch is connected to the tungsten wire cathode 9 externally of the apparatus.

To operate the apparatus, the solution 8 is initially brought up to between 40°C and 80°C either by preheating outside the apparatus or by passing power through a heating element in the solution (not shown). When the solution is between these temperatures it is either transferred to the above apparatus or,

if a heating element is used, this is turned off.

With all connections made as described, the switch is set to operate at a duty cycle of 1% and a pulse repetition frequency of 100Hz. It will be seen through the inspection cut-out that an intense plasma-arc is intermittently struck under the water at or near the cathode. If equipment is available to monitor the current drawn, it will be seen that the system consumes in the region of 1 watt when the switching circuits is operating. It will be seen by the rapid rise in temperature in the apparatus that far more energy is being released than can be accounted for by the electrical input. As a comparison, a heater element can be substituted for the electrodes and operated 1 watt and the effects observed. There is really no need for sophisticated calorimetry to verify that large quantities of energy are being released close to the cathode of the equipment, such is the magnitude of the reaction for the process, as compared to a test with a resistive heating element of the same input power.

The data obtained from a representative one-hour session with this apparatus as shown as Table 1, below:

Pre Run Measurements

Commencing volume of electrolyte	0.200	ℓ
Commencing temperature of cell	39.200	°C
Laboratory ambient temperature	20.500	°C
Spec. heat capacity of vessel	70.300	$J.°C^{-1}$
Spec. heat capacity of electrolyte	4180.000	$J.I^{-1}.°C^{-1}$
Steady RMS voltage	4.000	volts
Steady RMS current	0.067	Amps

Post Run Results

Duration of input	3600.000	secs
Final volume of electrolyte	0.180	ℓ
Final temperature of cell	93.600	°C

Steady RMS voltage	6.700	volts
Steady RMS current	0.122	Amps
Time-averaged power in	0.506	watts

Results Summary

Vessel Gain	3824.320	Joules
Electrolyte gain	43181.740	Joules
Radiated power	38681.030	Joules
Evaporated loss	48509.240	Joules
TOTAL ENERGY IN............	1820.070	Joules
TOTAL ENERGY OUTPUT........	134196.300	Joules

It can be seen from this table that the total energy input during this test was measured at 1820 Joules and, taking as a rough guideline that 200ml of water requires the input of 838 joules of energy to raise it by 1°C, then by direct heating the water would be expect to rise by some 2°C, bearing in mind radiative losses. In fact, during the experiment the water temperature was raised from 39.2°C to 93.6°C and considerable steam was also liberated. Furthermore, the calculated energy output of 134196 Joules does not take account of secondary effects such as light-energy output and Faradaic electrolysis.

A system suitable for operating the apparatus of Figure 1 is illustrated in a block diagram in Figure 2. A pulse generator 20 supplies a variable duty-cycle pulse waveform to a high voltage switch unit 22. The pulse waveform may be monitored on an oscilloscope 24 and its repetition frequency is displayed on a first frequency counter 26. A second frequency counter 28 is provided to monitor the clock speed of the switch unit 22. Power supply 30 is operable to apply a voltage between 0 and 360V to an electrode of the apparatus 12, shown in Figure 1. The voltage level may be read from a digital multimeter 32. The RMS voltage across the electrodes 9 and 10 is indicated on a multimeter 34

and the RMS current passing between the electrodes is shown on another multimeter 36, by measuring the voltages developed across a 1 ohm resistor 37. The temperature in the apparatus 12 is indicated on a dip temperature probe 38. The switch unit 22 may be bypassed by a push button switch 39 to apply a constant voltage across the electrodes.

A circuit diagram of the switch unit 22 is shown in Figure 3. In the system of Figure 2, input 40 is connected to the output of pulse generator 20. The output 42 of the switch unit is connected to the cathode of the apparatus 12. Two NAND gates 44 and 46 are two fourths of a Schmitt-trigger 2 input NAND gate chip type 4093. NAND gate 44 operates as an astable multivibrator, with its repetition frequency set by a preset resistor 45. The output of gate 44 is fed to one input of NAND gate 46, the other input forming circuit input 40. The output of NAND gate 46 is connected to a three transistor amplifier consisting of transistors 48, 50 and 52. The amplifier is in turn connected to one end of the primary of a transformer 54, the other end being connected to earth. The transformer output is fed to a bridge rectifier formed from diodes 56, 58, 60 and 62.

The rectifier output is fed via a resistor 64 to the gate of an insulated gate bipolar transistor 66 (IGBT). The load of the apparatus 12 is connected in the drain circuit of the IGBT. A 15kV diode 68 is connected between the drain and the source of the IGBT 66 to protect the IGBT from the sizeable EMI emissions from plasma discharges in the apparatus 12 and avoids damage to this sensitive semiconductor. A further diode 70 is provided between the drain of the IGBT and the circuit output 42 to act as an EMI blocker in a similar way. A standard 20mm 5A quick-blow fuse 69 is connected between the source of the IGBT and ground in order to protect the device against overcurrent.

The operation of the circuit of Figure 3 is as follows. The repetition frequency is NAND gate 44 is preferably set to between 4 and 6 MHz. Pulse generator 20 is adjusted to set the duty of

the switching. On receipt of an external pulse from the generator, NAND gate 46 passes a packet of 4 to 6 MHz square waves to the amplifier. The amplifier has considerable current gain and enables the primary of the transformer 54 to be driven resonantly with the RC circuit formed by capacitor 72 and resistor 74 which are connected in parallel therewith. The transformer 54 has a step-up ratio of 2:1 and a 4 to 6 MHz signal of approximately 19 volts appears across the bridge rectifier. The impedance of the rectifier output is essentially determined by a parallel resistor 76, such that the switch-on and switch-off time of the IGBT 66 is very fast. Thus, there is never a point in the operation of the device when it is dissipating any measurable power. The load of the apparatus 12 is placed in the drain circuit of the IGBT, which is therefore operating in "common-source" made to ensure that its source terminal never rises above high-side ground potential. This, again, is a configuration which uses excess input power. This circuit ensures a rise time of the switched waveform which is less than 10nS and a fall time which can be as low as 30nS at modest supply voltages.

Preferred component values and types for the circuit of Figure 3 are as follows:

Transistor 4, 50 - 2N 3649
Transistor 52 - 2N 3645
Diodes 56, 58, 60, 62 - BAT85 Schottky
Transformer 54 - RS195 - 460
IGBT 66 - GT8Q101
Diode 68 - 15kv EHT
Diode 70 - 1N1198A

Resistor	Value (Ω)	Capacitor	Value
47	1.8k	49	10pF
51	33	55	33nF
53	220	72	22pF
74	56		

76	560
64	56

A second apparatus for carrying out the invention is illustrated in Figure 4. This apparatus comprises a tubular chamber 80, which may be constructed from a nonmagnetic metal or metal alloy material such as, but not exclusively, aluminium or Duralumin, or may alternatively be constructed from a non-permeable ceramic material or from borosilicate glass. The tubular chamber 80 is constructed in flanged form to allow of its incorporation into a system of pipework via flanges 82 and 84 and gaskets 86. Entering the chamber 80 are two electrodes, the cathode 88 being sheathed in an insulating glass or ceramic tube 90 and shaped so as to present itself along the axis of the chamber 92. The anode 94 is connected to a similar insulated wire 96 and is shaped so as to present a circular plate opposite the cathode 88. The distance between the cathode tip and the anode plate should be approximately equal to the radius of the chamber 80. The cathode may be constructed from tungsten, zirconium, stainless steel, nickel or tantalum, or any other metallic or conductive ceramic material which may contribute to, or occasion, the dissociative process described above. The anode may be constructed from platinum, palladium, rhodium or any other inert material which does not undergo any significant level of chemical interaction with the electrolyte.

Surrounding the chamber 80, and concentric with it, is a winding 98 of enamelled copper or silver wire of diameter 0.1 to 0.8mm consisting of up to several thousand turns of the wire. The purpose of this winding 98 is to create an axial magnetic field inside the chamber 80.

Electrolyte comprising deuterium oxide, in combination with ordinary "light" water in varying proportions, and containing high-molarity salts of, but not exclusively of, potassium, rubidium or lithium, or combinations of such salts, is pumped through the chamber 80, in a direction such that the anode is

downstream of the cathode.

The anode lead wire 96 is connected to the ground plane or zero volts. The cathode 88 is connected to a variable source of between 50 and preferably 2000 volts negative with respect to the grounded anode 94, but may be coupled to a voltage of up to several tens of thousands of volts negative with respect to such anode 94. To enhance performance of the invention, the negative voltage may be supplied in the form of pulses having a duty cycle between 0.001 and 0.5.

The winding 98 is energised with an alternating voltage such as to provide a current flow of typically between 0.5 and 1.5 amps initially. The frequency of the applied alternating voltage should be variable from DC up to 15kHz and may, in addition, be synchronous with pulses applied to the cathode 88.

Under these conditions, a plasma arc will strike close to the cathode 88. The intensity and frequency of the current flowing in winding 98 may be adjusted to provide for the removal of the plasma arc from the immediate vicinity of the cathode 88 to avoid excessive evaporation of the material from the cathode 88.

The volume of electrolyte pumped through chamber 80 and past the plasma arc may be varied such as to stabilise the temperature of such electrolyte in a closed system at below at its boiling point.

Heat may be extracted from the electrolyte by passing it through a heat exchanger before its re-introduction into the chamber 80. Provision may be made to top-up the water/deuterium content of the electrolyte as this becomes depleted by operation of the apparatus. The system may operate at a range of pressures to facilitate heat removal.

A further apparatus for carrying out the invention, similar to that of Figure 4, is shown in Figure 5 on a scale of

approximately 1:2.5. It comprises a borosilcate reaction tube 100 supported at one end on a machined nylon support bridge 102. A second machined nylon element 104 is mounted across the other end of the tube. The bridge 102 and element 104 are clamped against the tube 100 by 8mm threaded stainless steel studs 110.

A first cathode 106 is in the form of a nickel wire mesh. It is mounted towards one end of tube 100 on a stainless steel support 108. Electrical connection to the first cathode 106 is via a PVC-sleeved wire (not shown).

A second cathode 112 consists of an 0.5mm diameter length of tungsten wire provided within a drilled macor ceramic sheath 114, which is in turn placed within a 10mm stainless steel tube 116. Tube 116 passes through the support 102 and has a perspex end cap 118 on the external end through which the second cathode 112 passes. A PVC funnel 120 is provided around the second cathode and is tapered towards it, with the cathode tip adjacent the narrower open end thereof. The funnel is supported on sleeves 121 provided on the stainless steel support 108.

The anode comprises an 0.25mm diameter platinum wire 122 which is connected at one end within the tube 100 to a sheet of platinum foil 124. Like the second cathode 112, the anode is provided within a 10mm diameter stainless steel tube 126, which passes through nylon element 104 and is closed at its external end by a perspex end cap 128. Platinum wire 122 passes through the end cap 128.

A plasma deflection coil 130 is mounted within tube 100 between the anode 124 and cathodes 106, 112. Electrical power is fed to the coil via connectors 132.

Electrolyte is supplied to the tube 100 via a brass inlet 134 provided through the support bridge 102 and flows out through nylon element 104 via a brass outlet 136. An additional brass outlet 138 is also provided in nylon element 104 to allow the

electrolyte to be sampled during operation of the apparatus. Fuse holders and cable connectors for the apparatus are provided in a unit 140 mounted on the support bridge 102.

The apparatus of Figure 5 is operated in a similar manner to that of Figure 4, as discussed above. The primary distinction is that two cathodes 106, 112 are employed in place of a single cathode. In use, electrolyte is fed through the tube 100, past the electrodes, from inlet 134 to outlet 136. A pulsed voltage is applied to the first cathode 106 such that a layer of metal hydride is formed on it surface during the voltage pulses and subsequently dissociates to form nascent monatomic hydrogen/deuterium. The applied voltage characteristics are selected to optimise the production rate of the monatomic hydrogen/deuterium. These products are channelled towards the second cathode 112 by the funnel 120. A voltage is applied to the second cathode 112 to generate a plasma discharge thereat.

The characteristics and magnitudes of the voltages applied to the first and second cathodes may be similar, but it may be advantageous for different duty periods to be employed for respective cathodes. This cathode arrangement with the second cathode downstream of the first seeks to maximise contact between the monatomic hydrogen/deuterium and the plasma and therefore the efficiency of the apparatus. This is further assisted by the funnel 120.

CLAIMS

1 A method of releasing energy comprising the steps of providing an electrolyte having a catalyst therein, the catalyst being suitable for initiating transitions of hydrogen and/or deuterium atoms in the electrolyte to a sub-ground energy state, and generating a plasma discharge in the electrolyte.

2 The method of Claim 1 wherein the plasma discharge is generated by applying a voltage across electrodes in the electrolyte.

3 The method of Claim 2 wherein the voltage is applied so as to produce an intermittent plasma discharge.

4 The method of Claim 2 or Claim 3 wherein the applied voltage is in the range 50 to 20000V.

5 The method of any of Claims 2 to 4 wherein the applied voltage is greater than 300V.

6 The method of any of Claims 2 to 5 wherein the applied voltage has a substantially square shaped waveform.

7 The method of any of Claims 2 to 6 wherein the applied voltage has a pulsed waveform having a duty cycle between 0.001 and 0.5.

8 The method of any of Claims 2 to 7 wherein the voltage is switched on and off by a switching assembly comprising an insulated gate bipolar transistor.

9 The method of any of Claims 2 to 8 wherein the applied voltage has a waveform having a frequency of between DC and 100 kHz.

10 The method of any of Claims 2 to 7 wherein a metal hydride is formed on an electrode which dissociates to form hydrogen and/or deuterium atoms.

11 The method of Claim 10 wherein the metal hydride is formed on an electrode during voltage pulses and subsequently dissociates to form hydrogen and/or deuterium atoms.

12 The method of any of Claims 2 to 11 wherein the current density generated by the applied voltage is 400,000 A/m^2 or above.

13 The method of any of Claims 2 to 12 comprising the step of feeding the electrolyte past the electrodes.

14 The method of Claim 13 wherein, after the step of feeding the electrolyte past the electrodes, the electrolyte is fed through a heat exchanger.

15 The method of Claim 14 wherein, after the step of feeding the electrolyte through the heat exchanger, it is fed back to the electrodes.

16 The method of any of Claims 2 to 15 further comprising the step of generating a magnetic field in the region of the electrodes.

17 The method of Claim 16 wherein the magnetic field is generated by supplying power to a winding surrounding the electrodes.

18 The method of Claim 17 wherein the frequency of the voltage applied across the winding is in the range from DC to 100MHz.

19 The method of any of Claims 16 to 18 wherein the magnetic field is arranged to cause the plasma discharge generated adjacent the cathode to be spaced therefrom.

20 The method of any of Claims 2 to 19 wherein hydrogen and/or deuterium atoms are formed using a first cathode and the voltage applied to generate the plasma discharge is applied across an anode and a second cathode.

21 The method of Claim 20 when dependent on Claim 13 or any claim dependent thereon wherein the second cathode is downstream from the first cathode.

22 The method of any of Claims 2 to 21 wherein a cathode electrode comprises tungsten, zirconium, stainless steel, nickel and/or tantalum.

23 The method of Claim 22 wherein a cathode electrode comprises a sheath of nickel foil wrapped on a substrate of tungsten, zirconium, stainless steel, and/or tantalum.

24 The method of any of Claims 2 to 23 wherein the anode electrode is formed of a material which is inert with respect to the electrolyte.

25 The method of Claim 24 wherein the anode comprises platinum, palladium and/or rhodium.

26 The method of any preceding claim wherein the temperature of the plasma is approximately 6000K or above.

27 The method of any preceding claim comprising the step of varying the ratio of catalyst to water in the electrolyte in the range 1 to 20 mMol.

28 The method of any preceding claim wherein the electrolyte comprises water and/or deuterated water and/or deuterium oxide.

29 The method of Claim 28 wherein the only reactive ingredient consumed by the reaction is water or deuterated water.

30 The method of Claim 28 or Claim 29 comprising the step of varying the ratio of water to deuterium oxide and/or deuterated water in the electrolyte to control energy generation.

31 The method of any preceding claim comprising the step of heating the electrolyte to a temperature between 40 to 80°C prior to generating the plasma discharge.

32 The method of any preceding claim wherein fusion occurs via at least one of the following pathways:

$^{2}_{1}D + ^{2}_{1}D = ^{3}_{2}He + ^{1}_{0}n$

or

$^{2}_{1}D + ^{2}_{1}D = ^{3}_{1}T + ^{1}_{1}H$

or

$^{1}_{1}H + ^{1}_{1}H = ^{2}_{1}D + ß^{+} + \tau$

33 Apparatus for carrying out the method of any preceding claim comprising an anode, first and second cathodes, a reaction vessel having an inlet and an outlet, means for feeding an electrolyte through the vessel from its inlet to its outlet, the electrolyte having a catalyst therein suitable for initiating transitions of hydrogen and/or deuterium atoms in the electrolyte to a sub-ground energy state, means for applying a voltage across the anode and the first cathode to form hydrogen and/or deuterium atoms, and means for applying a voltage across the anode and second cathode to generate a plasma discharge in the electrolyte, the second cathode being downstream from the first cathode.

34 Apparatus of Claim 33 including means for converging electrolyte flow towards the second cathode.

35 Apparatus of Claim 34 wherein the converging means is in the form of a funnel or nozzle.

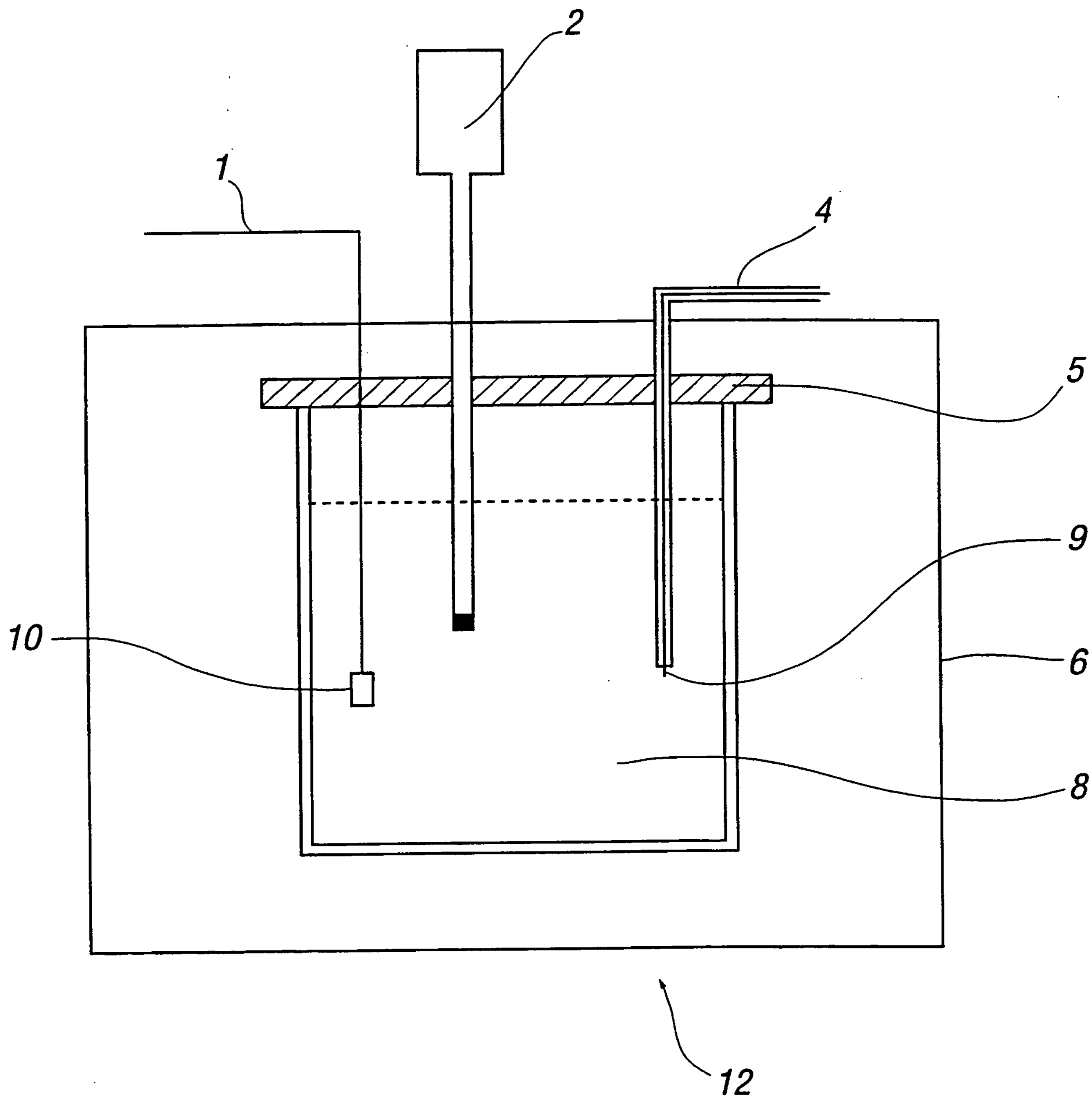

FIG. 1

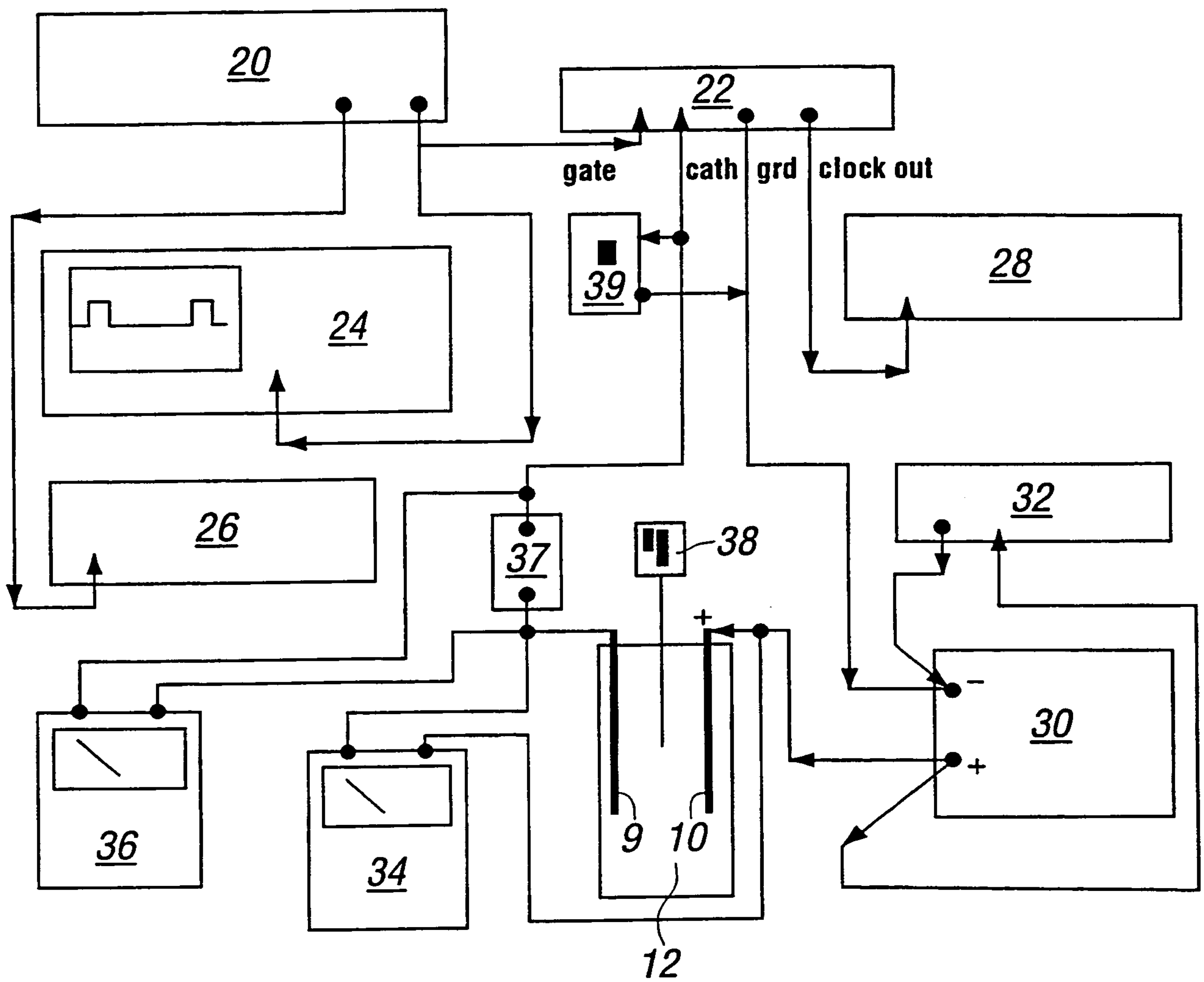

FIG. 2

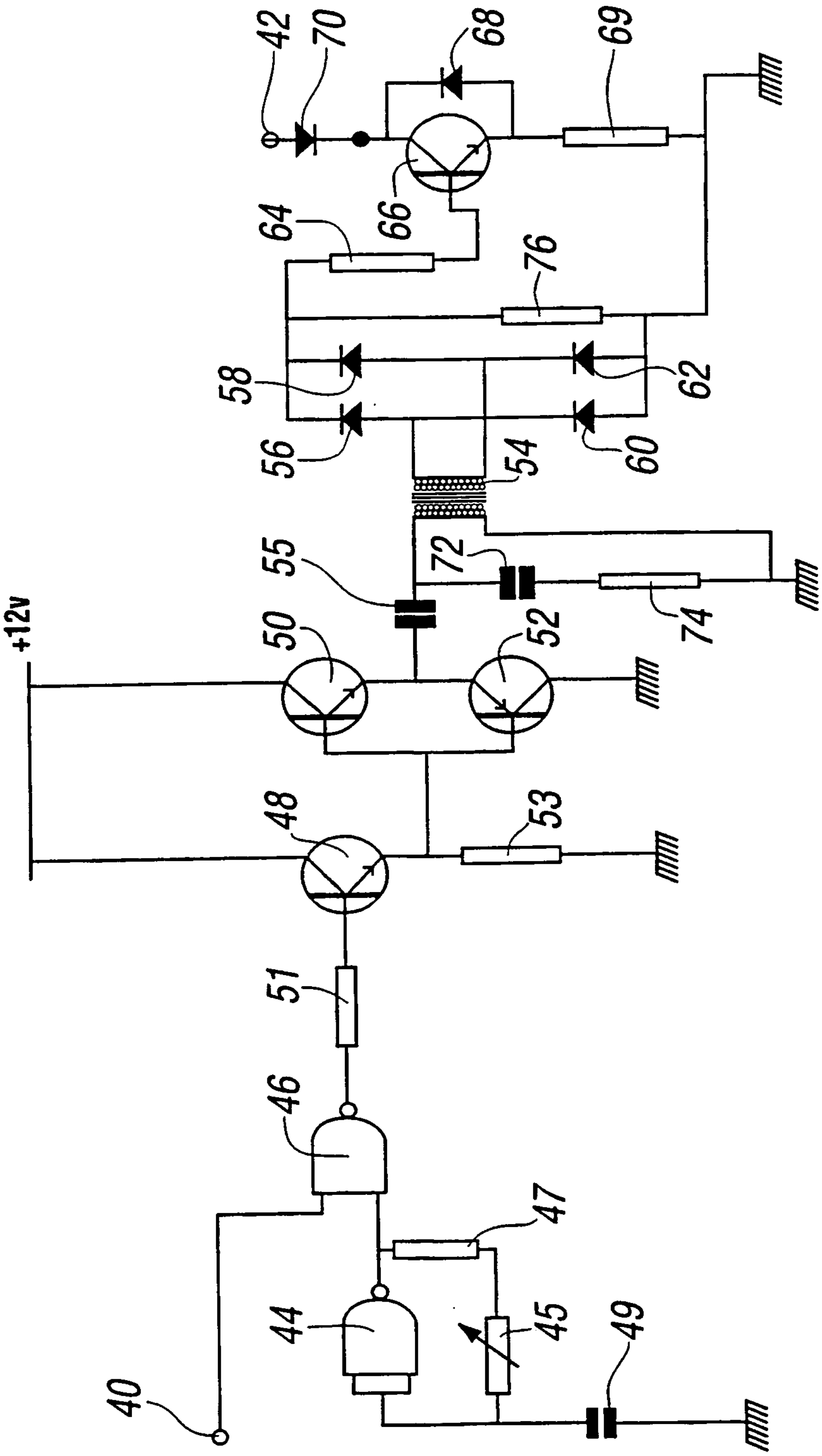
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FIG. 3

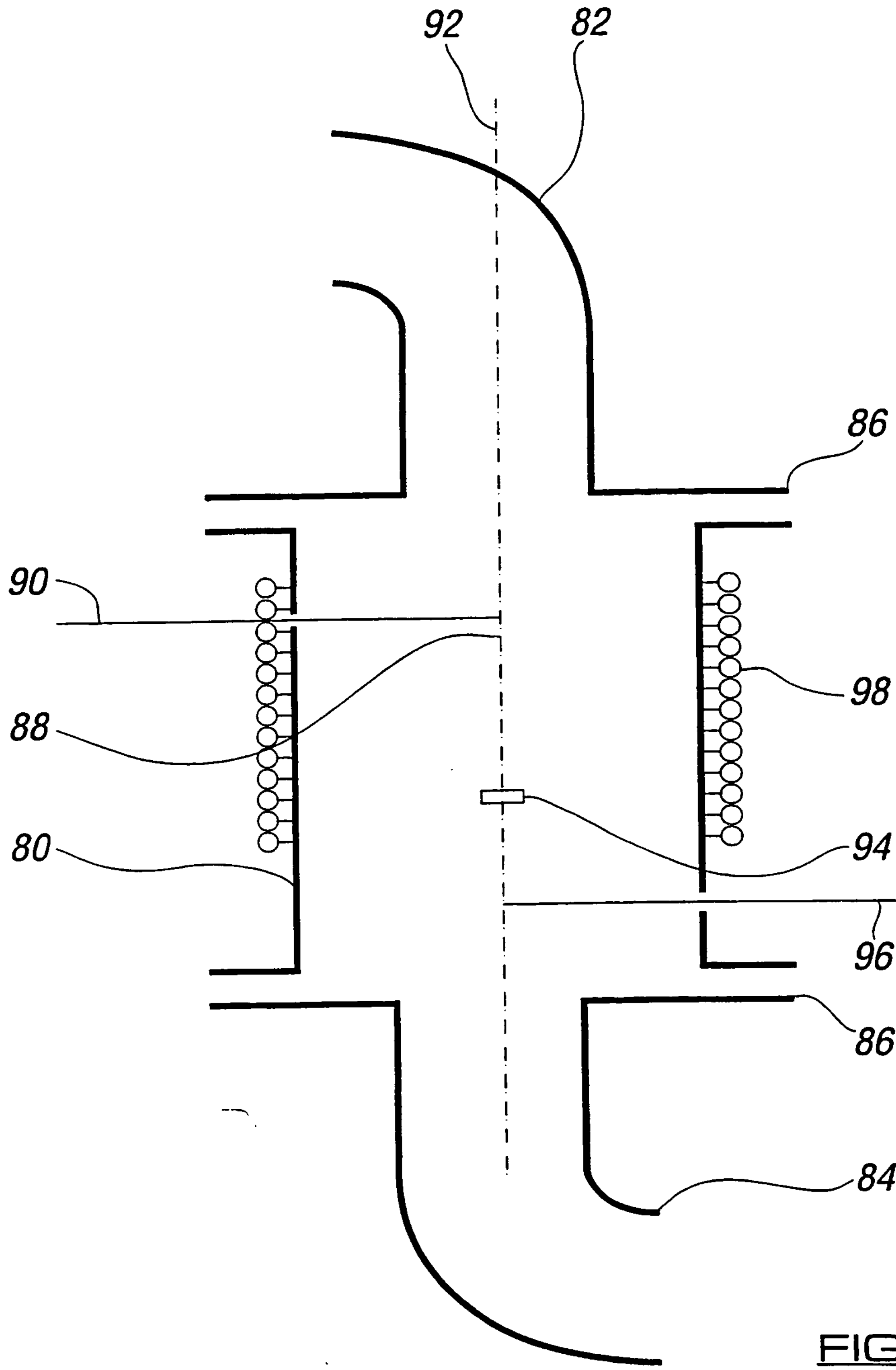

FIG. 4

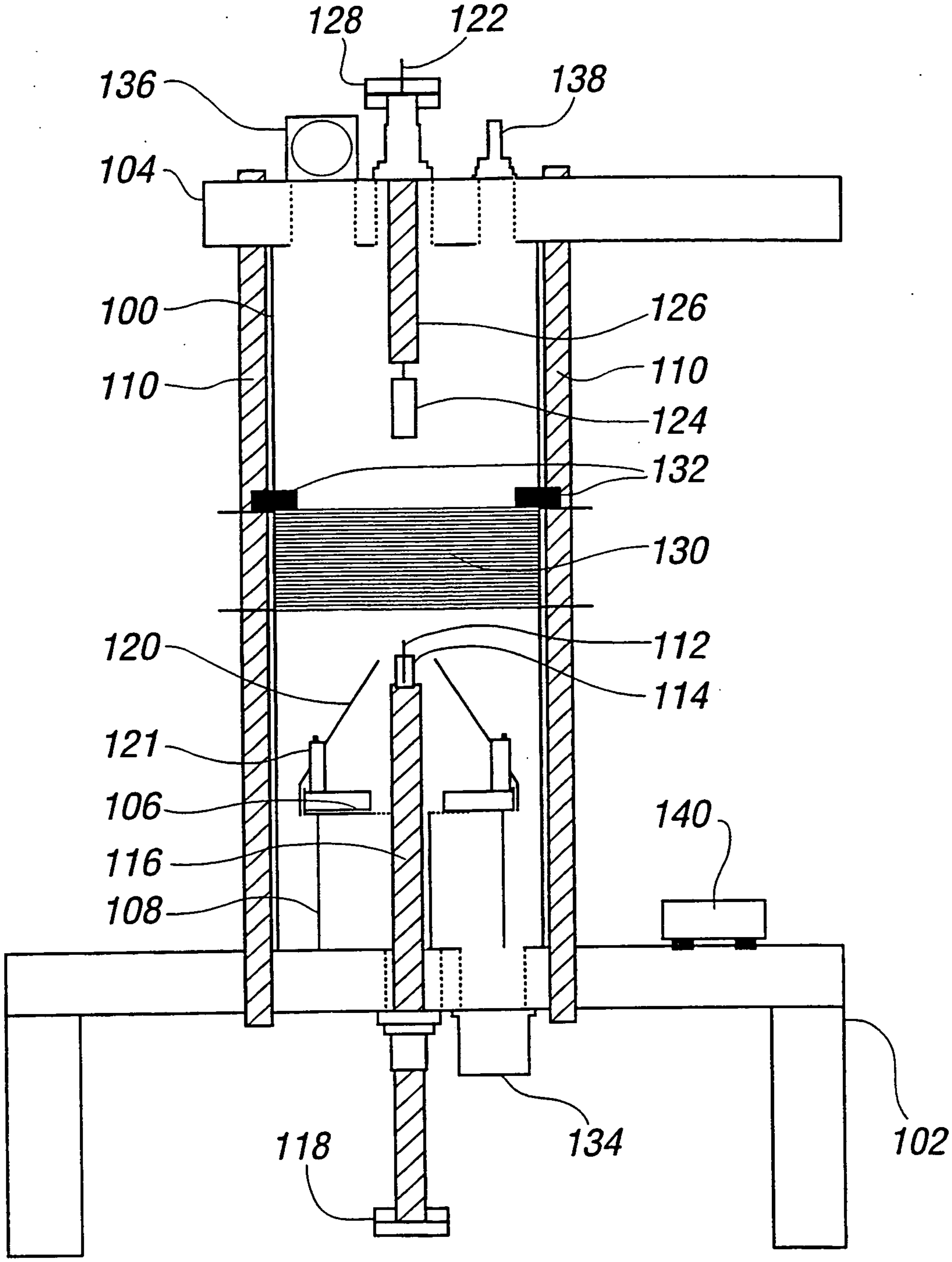
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FIG. 5

INTERNATIONAL SEARCH REPORT

Inte...ional Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G21B1/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 90 14669 A (TEKNISK UTVECKLING EHR AB) 29 November 1990 (1990-11-29)	1-5, 13-16, 24,25, 28,29,32
Y	page 2, line 34 -page 4, line 32 figure 1	8-10,22
Y	GB 2 277 215 A (MARCONI GEC LTD) 19 October 1994 (1994-10-19) page 5, paragraph 1 - paragraph 3	8,9
Y	PATENT ABSTRACTS OF JAPAN vol. 015, no. 079 (P-1170), 25 February 1991 (1991-02-25) & JP 02 297095 A (SEIKO EPSON CORP), 7 December 1990 (1990-12-07) abstract	10,22

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"O" document referring to an oral disclosure, use, exhibition or other means

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 January 2000	02/02/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Capostagno, E

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Int. ional Application No
PCT/GB 99/03523

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 015, no. 230 (P-1214), 12 June 1991 (1991-06-12) & JP 03 068894 A (TOYOAKI OMORI), 25 March 1991 (1991-03-25) abstract ---	1-3
A	EP 0 392 325 A (SEMICONDUCTOR ENERGY LAB) 17 October 1990 (1990-10-17) column 4, line 32 - line 47 claims 1,2 -----	6,7

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Int .tional Application No
PCT/GB 99/03523

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9014669 A	29-11-1990	SE 465443 B	09-09-1991
		DE 69024492 D	08-02-1996
		EP 0473681 A	11-03-1992
		JP 4505364 T	17-09-1992
		SE 8901798 A	20-11-1990
GB 2277215 A	19-10-1994	EP 0620645 A	19-10-1994
		US 5610507 A	11-03-1997
JP 02297095 A	07-12-1990	NONE	
JP 03068894 A	25-03-1991	NONE	
EP 0392325 A	17-10-1990	JP 2271290 A	06-11-1990

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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : G21B 1/00

A1

(11) International Publication Number: WO 00/25320

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(30) Priority Data:

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9904909.0	3 March 1999 (03.03.99)	GB

(71) Applicants (*for all designated States except US*): DAVIES, Christopher, John [GB/GB]; Westgate House, Dedham, Colchester, Essex CO7 6HJ (GB). DAVIES, Caroline, Jane [GB/GB]; Westgate House, Dedham, Colchester, Essex CO7 6HJ (GB). BEITH, Robert, Michael, Victor [GB/GB]; Wall View, Easton, Woodbridge, Suffolk IP13 0EF (GB).

(71)(72) Applicant and Inventor: ECCLES, Christopher, Robert [GB/GB]; Westgate House, Colchester, Essex CO7 6HJ (GB).

(74) Agent: HITCHCOCK, Esmond, Antony; Lloyd Wise, Tregear & Co., Commonwealth House, 1–19 New Oxford Street, London WC1A 1LW (GB).

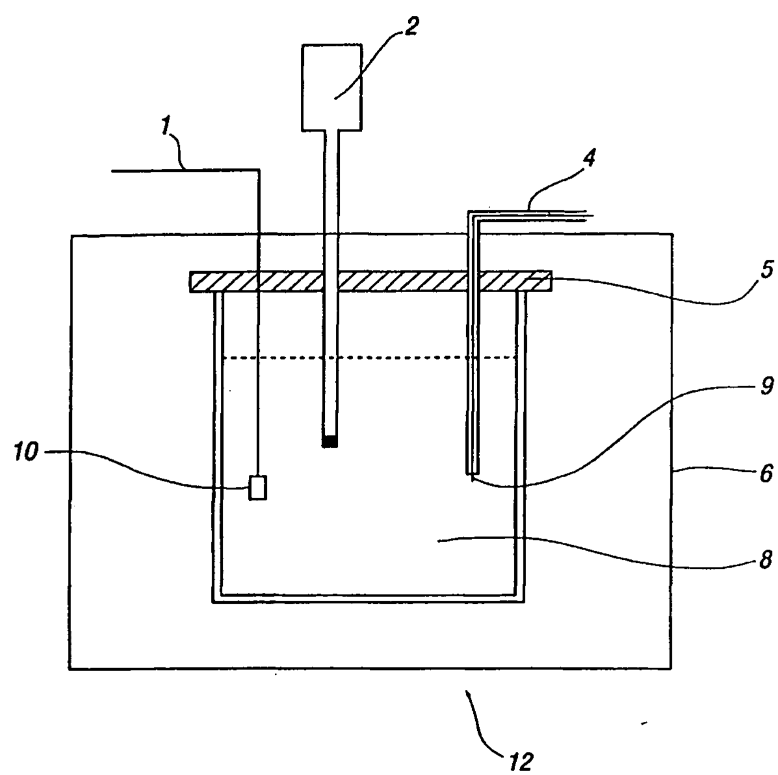
(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: ENERGY GENERATION

(57) Abstract

Methods and apparatus are described for releasing energy from hydrogen and/or deuterium atoms. An electrolyte is provided which has a catalyst therein suitable for initiating transitions of hydrogen and/or deuterium atoms in the electrolyte to a subground energy state. A plasma discharge is generated in the electrolyte to release energy by fusing the atoms together.



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INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 99/03523

A. CLASSIFICATION OF SUBJECT MATTER
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Y	PATENT ABSTRACTS OF JAPAN vol. 015, no. 079 (P-1170), 25 February 1991 (1991-02-25) & JP 02 297095 A (SEIKO EPSON CORP), 7 December 1990 (1990-12-07) abstract	10,22

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European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Capostagno, E

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 99/03523

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
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A	EP 0 392 325 A (SEMICONDUCTOR ENERGY LAB) 17 October 1990 (1990-10-17) column 4, line 32 - line 47 claims 1,2 -----	6,7

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
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		EP 0473681 A	11-03-1992
		JP 4505364 T	17-09-1992
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GB 2277215 A	19-10-1994	EP 0620645 A	19-10-1994
		US 5610507 A	11-03-1997
JP 02297095 A	07-12-1990	NONE	
JP 03068894 A	25-03-1991	NONE	
EP 0392325 A	17-10-1990	JP 2271290 A	06-11-1990

PATENT COOPERATION TREATY

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference SH/MC/44264	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/GB99/03523	International filing date *(day/month/year)* 25/10/1999	Priority date *(day/month/year)* 26/10/1998
International Patent Classification (IPC) or national classification and IPC G21B1/00		
Applicant DAVIES, Christopher, John et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 5 sheets, including this cover sheet.

   ☐ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☐ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand 25/05/2000	Date of completion of this report 09.01.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Frisch, K Telephone No. +49 89 2399 2559

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB99/03523

I. Basis of the report

1. This report has been drawn on the basis of *(substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments (Rules 70.16 and 70.17).)*:

Description, pages:

1-22 as originally filed

Claims, No.:

1-35 as originally filed

Drawings, sheets:

1/5-5/5 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB99/03523

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

☒ the entire international application.

☐ claims Nos. .

because:

☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination (*specify*):

☒ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. are so unclear that no meaningful opinion could be formed (*specify*):
see separate sheet

☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.

☐ no international search report has been established for the said claims Nos. .

2. A meaningful international preliminary examination report cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

☐ the written form has not been furnished or does not comply with the standard.

☐ the computer readable form has not been furnished or does not comply with the standard.

INTERNATIONAL PRELIMINARY EXAMINATION REPORT - SEPARATE SHEET International application No. PCT/GB99/03523

Concerning Part III; No opinion concerning novelty and inventive step:

An essential step of the method defined in claim 1 comprises providing a catalyst which is suitable for initiating transitions of hydrogen and/or deuterium atoms in an electrolyte to a sub-ground energy state. Similarly, an essential feature of the apparatus defined in claim 33 comprises an electrolyte having such a catalyst. It is, however, completely obscure which materials may constitute such a catalyst, it being unknown which materials may have the stated catalyst property. In fact, no material is known to have the stated property. Also, and contrary to the opinion of the applicant, the skilled person cannot without excessive experimentation determine whether or not a particular material has the stated catalytic property, since it is not known under which circumstances the catalytic activity should be expected. In other words, the skilled person would not know which experiments to conduct in order to determine whether a given material is a catalyst of the kind stated in claims 1 and 33. It is therefore not possible to generalize from the few kinds of materials (Rb+, K+, Ti++) mentioned on page 9 of the present description.

Furthermore, no material has been shown by the applicant to have the stated catalyst property. In the present description (page 9) a few kinds of materials (Rb+, K+, Ti++) are mentioned, but none of these have experimentally been shown by the applicant to be capable of initiating the relevant energy state transitions in hydrogen atoms, such that not even those few materials mentioned by the applicant have been demonstrated to constitute catalysts of the kind stated in claims 1 and 33. The embodiments explained in the description in connection with figures 1 and 4 include electrolytes comprising salts of potassium, rubidium or lithium (page 14, line 10; page 19, last paragraph), but there is presented no evidence that these embodiments comprise catalysts capable of producing hydrogen atoms in a sub-ground energy state.

The scope of independent claims 1 and 33 - and therefore also of the dependent claims 2-32 and 34-35 - is therefore so unclear that no comparison with prior art is possible. Hence, no opinion can be formed with respect to novelty and inventive step of the claimed subject-matter.

It is noted that the claimed subject-matter is based on the general idea that hydrogen isotope atoms may exist in sub-ground energy states and that "normal" (ground state) hydrogen atoms can be induced to undergo transition into such states. This general idea is, however, mere theory which is not supported by unambiguous experimental evidence and which is not generally accepted in the scientific community. The present description, too, is purely theoretical in this respect (see the explanation given in the description on pages 4-13); it provides no experimental evidence proving in an unambiguous manner the existence of hydrogen atoms in sub-ground energy states. For example, page 6 (line 14) states that "fractional values for n are allowed", but no experimental evidence showing the existence of hydrogen atoms having such fractional values of n is provided. The alleged observation of a galactic cluster emission at a wavelength of about 30.8 nm (see description, page 10, last paragraph) cannot immediately be seen to prove that hydrogen atoms exist in a sub-ground energy state.

PATENT COOPERATION TREATY

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

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International application No. PCT/GB99/03523	International filing date *(day/month/year)* 25/10/1999	Priority date *(day/month/year)* 26/10/1998
International Patent Classification (IPC) or national classification and IPC G21B1/00		
Applicant DAVIES, Christopher, John et al.		

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   III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   IV ☐ Lack of unity of invention
   V ☐ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   VI ☐ Certain documents cited
   VII ☐ Certain defects in the international application
   VIII ☐ Certain observations on the international application

Date of submission of the demand 25/05/2000	Date of completion of this report 09.01.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Frisch, K Telephone No. +49 89 2399 2559

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB99/03523

I. Basis of the report

1. This report has been drawn on the basis of *(substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments (Rules 70.16 and 70.17).)*:
   Description, pages:

   1-22 as originally filed

   Claims, No.:

   1-35 as originally filed

   Drawings, sheets:

   1/5-5/5 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   - ☐ the description, pages:
   - ☐ the claims, Nos.:

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

   ☒ the entire international application.

   ☐ claims Nos. .

because:

☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination (*specify*):

☒ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. are so unclear that no meaningful opinion could be formed (*specify*):
see separate sheet

☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.

☐ no international search report has been established for the said claims Nos. .

2. A meaningful international preliminary examination report cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

   ☐ the written form has not been furnished or does not comply with the standard.

   ☐ the computer readable form has not been furnished or does not comply with the standard.

Concerning Part III; No opinion concerning novelty and inventive step:

An essential step of the method defined in claim 1 comprises providing a catalyst which is suitable for initiating transitions of hydrogen and/or deuterium atoms in an electrolyte to a sub-ground energy state. Similarly, an essential feature of the apparatus defined in claim 33 comprises an electrolyte having such a catalyst. It is, however, completely obscure which materials may constitute such a catalyst, it being unknown which materials may have the stated catalyst property. In fact, no material is known to have the stated property. Also, and contrary to the opinion of the applicant, the skilled person cannot without excessive experimentation determine whether or not a particular material has the stated catalytic property, since it is not known under which circumstances the catalytic activity should be expected. In other words, the skilled person would not know which experiments to conduct in order to determine whether a given material is a catalyst of the kind stated in claims 1 and 33. It is therefore not possible to generalize from the few kinds of materials (Rb+, K+, Ti++) mentioned on page 9 of the present description.

Furthermore, no material has been shown by the applicant to have the stated catalyst property. In the present description (page 9) a few kinds of materials (Rb+, K+, Ti++) are mentioned, but none of these have experimentally been shown by the applicant to be capable of initiating the relevant energy state transitions in hydrogen atoms, such that not even those few materials mentioned by the applicant have been demonstrated to constitute catalysts of the kind stated in claims 1 and 33. The embodiments explained in the description in connection with figures 1 and 4 include electrolytes comprising salts of potassium, rubidium or lithium (page 14, line 10; page 19, last paragraph), but there is presented no evidence that these embodiments comprise catalysts capable of producing hydrogen atoms in a sub-ground energy state.

The scope of independent claims 1 and 33 - and therefore also of the dependent claims 2-32 and 34-35 - is therefore so unclear that no comparison with prior art is possible. Hence, no opinion can be formed with respect to novelty and inventive step of the claimed subject-matter.

It is noted that the claimed subject-matter is based on the general idea that hydrogen isotope atoms may exist in sub-ground energy states and that "normal" (ground state) hydrogen atoms can be induced to undergo transition into such states. This general idea is, however, mere theory which is not supported by unambiguous experimental evidence and which is not generally accepted in the scientific community. The present description, too, is purely theoretical in this respect (see the explanation given in the description on pages 4-13); it provides no experimental evidence proving in an unambiguous manner the existence of hydrogen atoms in sub-ground energy states. For example, page 6 (line 14) states that "fractional values for n are allowed", but no experimental evidence showing the existence of hydrogen atoms having such fractional values of n is provided. The alleged observation of a galactic cluster emission at a wavelength of about 30.8 nm (see description, page 10, last paragraph) cannot immediately be seen to prove that hydrogen atoms exist in a sub-ground energy state.

A D

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
EH/DS/44264		
International application No. PCT/GB 99/ 03523	International filing date (*day/month/year*) 25/10/1999	(Earliest) Priority Date (*day/month/year*) 26/10/1998
Applicant DAVIES, Christopher, John et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

      [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

      [ ] contained in the international application in written form.
      [ ] filed together with the international application in computer readable form.
      [ ] furnished subsequently to this Authority in written form.
      [ ] furnished subsequently to this Authority in computer readble form.
      [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
      [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

   [X] the text is approved as submitted by the applicant.
   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

   [X] the text is approved as submitted by the applicant.
   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 1

   [ ] as suggested by the applicant.
   [X] because the applicant failed to suggest a figure.
   [ ] because this figure better characterizes the invention.
   [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 99/03523

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G21B1/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 90 14669 A (TEKNISK UTVECKLING EHR AB) 29 November 1990 (1990-11-29)	1-5, 13-16, 24,25, 28,29,32
	page 2, line 34 -page 4, line 32	
Y	figure 1	8-10,22

Y	GB 2 277 215 A (MARCONI GEC LTD) 19 October 1994 (1994-10-19) page 5, paragraph 1 - paragraph 3	8,9

Y	PATENT ABSTRACTS OF JAPAN vol. 015, no. 079 (P-1170), 25 February 1991 (1991-02-25) & JP 02 297095 A (SEIKO EPSON CORP), 7 December 1990 (1990-12-07) abstract	10,22

	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 January 2000	02/02/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Capostagno, E

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 015, no. 230 (P-1214), 12 June 1991 (1991-06-12) & JP 03 068894 A (TOYOAKI OMORI), 25 March 1991 (1991-03-25) abstract ---	1-3
A	EP 0 392 325 A (SEMICONDUCTOR ENERGY LAB) 17 October 1990 (1990-10-17) column 4, line 32 - line 47 claims 1,2 -----	6,7

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 99/03523

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9014669 A	29-11-1990	SE 465443 B	09-09-1991
		DE 69024492 D	08-02-1996
		EP 0473681 A	11-03-1992
		JP 4505364 T	17-09-1992
		SE 8901798 A	20-11-1990
GB 2277215 A	19-10-1994	EP 0620645 A	19-10-1994
		US 5610507 A	11-03-1997
JP 02297095 A	07-12-1990	NONE	
JP 03068894 A	25-03-1991	NONE	
EP 0392325 A	17-10-1990	JP 2271290 A	06-11-1990